SYNOPSIS OF RESEARCH PROJECT

ON

STUDIES ON PEST SUCCESSION AND MANAGEMENT OF *Spodoptera litura* (Fab.) AND *Helicoverpa armigera* (Hub.) INFESTING GROUNDNUT

UNDER THE GUIDANCE OF

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SYNOPSIS OF RESEARCH PROJECT

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9. Introduction

Groundnut [*Arachis hypogaea* (L.)] is an annual, self-pollinated, allotetraploid (2n = 4x = 40) significant oilseed and food legume crops cultivated worldwide. It belongs to the family Fabaceae (Leguminosae) and sub-family Papilionoideae. This crop is unique among legumes due to its geocarpic fruiting habit, where fertilized flowers develop pegs that penetrate into soil and form pods underground (Gregory *et al*., 1951). Groundnut is also known as earthnut, peanut, goober, goober pea, pinda, jack nuts, monkey nuts and manila nuts. The last name is often used to refer to the whole pod.

Groundnut has been originated in South America, particularly in the regions near southern Bolivia and Northern Argentina, from where it spread to other parts of the world through Spanish and Portuguese explorers (Krapovickas and Gregory, 1994). Globally, groundnut is cultivated across tropical and subtropical regions between 40 °N and 40 °S latitudes. Major producing countries include China, India, Nigeria, United States and Sudan (Anon., 2023).

Groundnut plant possesses a well-developed taproot system with numerous lateral roots and nodules formed through symbiotic association with *Rhizobium* bacteria enabling biological nitrogen fixation. The stem is cylindrical, hairy and exhibit either prostrate or erect growth habit depending on the variety. Leaves are alternate, tetra foliate with two pairs of opposite leaflets. Groundnut bears yellow to orange flowers in axillary clusters; after self-pollination, the ovary elongates to form a gynophore (peg) that grows downward into soil, where the pod develops. The fruit is an indehiscent, reticulated pod containing one to four seeds enclosed within a thin testa (Smartt, 1994; Krapovickas and Gregory, 1994). Its haulms and leaf litter enrich the soil with organic matter; improving microbial activity, aggregation and soil structure. As a result, groundnuts are essential to crop rotation systems, especially in dryland agriculture; where they promote sustainable production and enhance soil health. (Smartt, 1994; Giller, 2001).

Groundnut seeds are widely consumed as raw, roasted, peanut butter, protein bar, in chocolates making *etc*. Oil extracted from seeds is used for cooking, frying and salad dressing due to its mild flavour and higher smoking point. Groundnut meal, a byproduct of oil extraction, haulm, leaves, stems and shells are essential components in animal feed. Its high protein content makes it an ideal supplement for livestock and poultry. Furthermore, groundnut shells are used as bio-fuel; serving as a renewable energy source. Groundnut earns its reputation as the "ideal legume" because it operates on a ‘zero-waste principle’ because every part of the plant serves a valuable purpose.

Groundnuts are very nutritional, making them valuable to a balanced diet to fight malnutrition. Groundnut is excellent source of plant-based protein (25-28%) in kernels and oil (48-50%). In addition, kernels provide many enhancing nutrients such as minerals – K, P, Mg *etc*. Among these minerals is magnesium, which supports bone health and regulates blood pressure. Phosphorus, another essential mineral found in groundnuts, aids in energy metabolism and plays a vital role in maintaining healthy teeth and bones (Janila *et al*., 2013).

Groundnut is tropical and sub-tropical legume well adapted to a wide range of ecological conditions particularly semi-arid and sub-humid. Groundnut performs optimally at temperatures between 25-30 °C and requires moderate, well-distributed rainfall (500-1000 mm) during the growing season. It exhibits considerable tolerance to intermittent drought due to its deep taproot system and efficient stomatal regulation (Boote, 1982; Smartt, 1994). Groundnut is predominantly cultivated under rainfed

conditions in light-textured soils and shows better adaptation to sandy loam and loamy -sand soils that facilitate peg penetration and pod development. It is sensitive to waterlogging and poorly drained heavy clay soils, as excess moisture adversely affects root respiration, nodulation and pod formation (Reddy, 1988). The crop thrives in well -drained soils with a pH range of 6.0-7.5.

In India, during 2024-25 about 6.70 million ha area covered under groundnut with production of 9.62 million tonnes. Gujarat, Rajasthan, Madhya Pradesh Uttar Pradesh and Andhra Pradesh are leading states in groundnut production (Anon., 2025a).

In Gujarat, during 2024-25 about 1.91 million ha area was covered under groundnut with a production of 5.09 million tonnes in K*harif* and also 0.06 million ha area covered with a production of 0.13 million tonnes in the summer season. The major districts growing this crop include Rajkot, Junagadh, Devbhumi Dwarka, Jamnagar and Amreli (Anon., 2025a).

In Junagadh district, during 2022-23 about 0.211 million ha area was covered under groundnut with a production of 0.62 million tonnes in *Kharif* and also 1165 ha area covered with a production of 2915 tonnes in the summer season (Anon., 2024a).

Among numerous biotic and abiotic factors that responsible for low yield, insect pests are recognised as one of the primary barriers to groundnut production, causing large losses in India (Singh, 1980). The only factor contributing to 10-20% crop loss and 10-25% post-harvest loss of groundnut output in India is insect pest infestation. Among these, insect pests are a significant limiting factor that results in significant crop losses in underdeveloped nations. The adoption of poor management practices, such as excessive pesticide use, inadequate crop rotation and unfavourable storage conditions, is one of the primary drivers of pest outbreaks (Joshi, 2020). Pests have a detrimental effect on both human health and crop productivity (Tandi *et al*., 2014; Misca *et al*., 2014 and Datcu *et al*., 2019). Farmers worldwide are estimated to spend more than $10 billion a year on insect-pest control (Van Lenteren, 2005).

Groundnut insect pests cause significant losses to the crop both; directly, as defoliators, sapsuckers and root feeders *etc*. and indirectly, as carriers of the viral diseases. In various places of the world, over 350 insect species cause significant damage to the crops (Stalker and Campbell, 1983).

Groundnut crops can be affected by several insect pests that can cause significant damage and reduce yields. The key insect pests affecting the crop and its yield (Vijaya *et al*., 2010) as below:

1. Leaf eating caterpillar : *Spodoptera litura* (Fabricius)
2. Pod borer : *Helicoverpa armigera* (Hubner)
3. Leaf miner : *Aproerema modicella* (Deventer)
4. White grub : *Holotrichia consanguinea* (Hope)
5. Hairy caterpillar : *Amsacta albistriga* (Walker) and *A. moorie* (Walker)
6. Aphid : *Aphis craccivora* (Koch)
7. Thrips : *Scirtothrips dorsalis* (Dist)
8. Jassid : *Empoasca kerri* (Pruthi)
9. Whitefly : *Bemisia tabaci* (Gennadius)

According to Dabhade *et al.* (2012) the avoidable yield loss due to major insect pests in groundnut was recorded up to 48.57% in pod and 42.11% in fodder. Ahir *et al.* (2018) stated that insect pests caused 35.71% (8.05 q/ha) loss in yield. Priyanka *et al.* (2025) revealed that major insect pest caused a mean reduction of plant height (22%), primary branches (29.1%), pods/plant (54.6%) and reduction of kernels/plant (44.5) in groundnut. Jethva and Bhut (2020) concluded that lepidopteron defoliators *viz*., *H. armigera* and *S. litura* are most serious problems in groundnut crop.

10. Practical Utility of the Research Project

Gujarat, mainly Saurashtra region has seen a steady growth in groundnut, which has resulted in rise in number of defoliator pests. Succession of pests explains that how various stages of groundnut (seedlings to pod filling) serve as bio indicators for specific insects. Succession shows that how one species follows another and how natural enemies react to these changes by recording the chronological succession of pests. A predictive ecological map of crop ecosystem can be produced by correlating these trends with weather parameters. Succession offers better comprehension of the complex trophic structure and population dynamics of groundnut field.

It is important to screen different cultivars to check for their resistance against insect pests under optimum levels of infestation and similar environmental conditions. However, there is need to develop cultivars with multiple resistances to pests and diseases that will be in greater demand in future for sustainable crop production and this requires a concerted effort from scientists involved in crop improvement programs.

Nowadays, repeated use of same class of pesticides for pest control cause undesirable changes in gene pool of the pest leading to pesticide resistance. The mixture of different mode of action insecticides is considered the most effective to break down resistance in insects. By testing ready-mixed formulations, we can determine if these

products offer better control than solo insecticides and potentially reducing the number of spray applications required per season. Hence, it is necessary to evaluate the efficacy of these chemicals against pests of groundnut.

Studies on relative persistence toxicity of insecticides help to determine how long it remain effective and toxic; which helps in appropriate pesticide selection, application scheduling, environmental protection and sustainable pest management. Relative toxicity serves as ready reckoner for selection of suitable insecticide for effective pest control in field. Also, this baseline data could provide record for detecting resistance level of pest to various insecticides at different periods.

Synergism of oils with NPVs significantly enhances pest control by addressing environmental limitations of the virus used alone. Standard water-based NPV is not able to stick on waxy and hairy plant leaves and is extremely sensitive to UV light. Oil based product act as protective shield and surfactant. This oil creates a thin and uniform film that resists washing off and prevents denaturing the viral DNA by sunshine, thereby extending its field persistence. Also, many plant oils act as phagostimulants, masking the presence of virus and encouraging defoliators to consume treated foliage more readily. This makes the treatment more effective and economical than using the virus alone because it increases the rate of viral ingestion at lower concentrations.

Keeping in view of these, the present studies on "Studies on pest succession and management of *Spodoptera litura* (Fab.) and *Helicoverpa armigera* (Hub.) infesting groundnut" will be carried out during two consecutive year *Kharif*, 2026 and 2027 at Main Oilseeds Research Station, JAU, Junagadh with the following objectives.

11. Objectives

1. To investigate the succession of major insect pests infesting groundnut
2. To screen different varieties/genotypes against *S. litura* and *H. armigera* infesting groundnut
3. To evaluate different ready-mixed insecticides against *S. litura* and *H. armigera* infesting groundnut
4. To determine the relative persistent toxicity of various insecticides against *S. litura* and *H. armigera* infesting groundnut
5. To evaluate *Sl*NPV with plant oils for the management of *S. litura* infesting groundnut
6. To evaluate *Ha*NPV with plant oils for the management of *H. armigera* infesting groundnut

12. Review of Literature

12.1 Succession of major insect pests infesting groundnut

Harish *et al.* (2015) conducted research trial in groundnut at IIGR, Junagadh (Guj.) and concluded that population of *S. litura* was recorded throughout *Kharif* season where, it started increasing gradually at starting of season and reached at its peak at the end of 40th SMW and then declined by the end of season. While, *H. armigera* started to appear in *Kharif* season from 29th SMW and reached its maximum at the end of 42nd SMW. The maximum leafhoppers were recorded at the end of 41st SMW and then after started declining. The maximum population of thrips were recorded at the end of 27th SMW.

Duraimurugan (2018) noticed that the peak oviposition (2.0 to 14.8 egg -masses/5 plants) and larval incidence (14.4 to 48 larvae/5 plants) of *S. litura* recorded during mid-August to mid-November (33rd to 46th SMW) coinciding with vegetative to primary spike development stage of the crop.

Gocher and Ahmad (2019) carried out field study for major pests infesting groundnut at Jobner (Raj.) and observed that aphid and leafhopper population commenced in last week of July and reached to their peak in the second week of September. Population of both pests showed significant negative correlation with maximum temperature and significant positive correlation with relative humidity.

Kumbhar (2021) studied population fluctuations of groundnut pests at Latur (Maharashtra) indicate that leaf miner incidence prevailed during last week of November to first week of March and peaked during first week of January. It's population positively influenced by morning and evening relative humidity. The peak activity of hairy caterpillar was in 1st SMW and was found negatively influenced by maximum and minimum temperature. The population of aphids, leafhoppers, whiteflies and thrips remained throughout the crop period with highest occurrence during 1st and 10th SMW. The aphids and leafhoppers population influenced by evening and morning relative humidity. The whiteflies and thrips incidence was found positively influenced by maximum temperature and minimum temperature while predator population was maximum in 1st SMW and positively correlated with morning relative humidity.

Venkata *et al.* (2023) studies on seasonal incidence of major insect pests in groundnut at ANGAU, Darsi (AP). The results indicated that the leaf miner (*A. modicella*) reached peak in the 1st week of September and the larval population of *S. litura* was more abundant on the crop during 2nd week of October. Aphid touched the

peak in the 1st week of September; whereas, leaf hopper attained the peak in the 2nd week of September. Maximum activity of thrips was recorded in the 2nd week of October.

Bharghavi *et al.* (2024) examined the frequency of pests in groundnut crop at Dharwad (Karnataka). Based on results she concluded that the population range of leafhoppers *viz*., 4.00 to 38.25 and 9.58 to 25.14/10 plants, thrips *viz*., 4.25 to 35.00 and 3.10 to 23.5/10 plants and whiteflies *viz*., 2.00 to 19.10 and 1.00 to 16.05/10 plants in JL-24 and Dh-256, respectively. Coccinellids were reported from seedling to pod filling stage in JL-24 (4.00 to 28.0/10 plants) and seedling to pegging and pod formation in Dh-256 (10 to 25.00/10 plants). Spiders were recorded from flowering to harvesting recorded in JL-24 (15.00 to 18.54/10 plants) and Dh-256 (6.18 to 15.00/10 plants).

Ongolu *et al.* (2024) recorded that the *S. litura* population initially appeared during 38th SMW in groundnut. Leaf miner incidence was confined to early stage of crop which was started at 38th SMW and highest incidence was in 41st SMW. The maximum leafhoppers population was noticed at 50th and 51st SMW. While, highest thrips damage occurred at 47th SMW. Leaf miner, *S. litura* and thrips showed a direct correlation with Tmax, Tmin, RH-I and RH-II.

Yadav *et al.* (2025) conducted field trial on pest complex of groundnut at Jhansi (UP) and stated that occurrence of leaf miner started in the 30th SMW (3rd week of July) and gradually increased and peaked in the 33rd SMW (4th week of august). Aphid was started in the 30th SMW (1st week of August) and gradually increased and peaked at 37th SMW (2nd week of September). While, *S. litura* population began in the 30th SMW (1st week of August) and gradually increased and peaked at 32nd SMW (3rd week of September). Jassid population first observed in the 30th SMW (2nd week of August) and gradually increased and peaked at 36th SMW (2nd week of September).

Gourav *et al*. (2026) revealed that the prevalence of leaf miners in groundnut started from 31st SMW, peaked on the 34th SMW and then declined to minimum. While, whitefly initially came on the 31st SMW and peaked on the 36th SMW, whereas leaf hopper first appeared on the 33rd SMW and peaked on the 36th SMW.

12.2 Screening of different varieties/genotypes against *S. litura* and *H. armigera* infesting groundnut

S. litura

Singh *et al.* (1993) identified that ICGV 87264, ICGV 86350 and ICGV 86276 lines had less leaf damage (< 17.5%) and higher pod yield over JL-24 under highest

pest load. Under free choice test of 15 groundnut genotypes BG-2, A. Virginia bunch variety showed resistance to *S. litura* and *H. armigera*.

Nadaf *et al.* (1995) reported that genotypes of groundnut ICGV-86350, ICGV-87264, ICGV-87165 and GBFDS-273 showed consistent superiority for resistance to defoliators over national check JL-24 for pod yield under protected as well as unprotected conditions.

Krishnaiah (2011) concluded that groundnut cultivars *viz.*, ICG (FDRS-79) and bheema recorded lowest mean larval population of S. *litura and H. armigera*. Based on leaf damage, cultivars *viz.*, ICG (FDRS-79), bheema and TCGS-901(A) are considered as moderately resistant to *S. litura.*

Waykule *et al.* (2020) recorded population of *S. litura* infesting groundnut at Latur (Maharashtra) and stated that the lowest *S. litura* was recorded on germplasm IES-I-2019-3 (1.05 larvae/5 plants) which is resistant germplasm. Highest number of *S. litura* were reported on IES-I-2019-4 *i.e.* (28.02 larvae/5 plants).

Dudhatra *et al.* (2024a) at JAU, Junagadh (Gujarat) conducted a research trial to screen different groundnut genotypes/varieties against *S. litura* in *Kharif*, 2023. According to findings, they revealed that JVB-2597 exhibited the lowest number of larvae (0.55 larvae/plant) and JVB-2577 showed the highest number of larvae (2.01 larvae/plant). From the categorization, it could be stated that JVB-2597, JSSP-76, JB-1572, J-108 and JVB-2607 are resistant and JSSP-69, JB-1585, J-118, J-111 and JVB-2577 are susceptible against *S. litura*.

H. armigera

Mayuravalli (1987) found that groundnut cultivars *i.e.*, TCG 384, TCG 273, TCG 1703, POL 1, TCG 638, TCG 651, TCG 291, TCG 221 and TCG 1707 were found moderately resistant; while TG 3, S 206, TCG 721, EC 21137-1, TCG 369, TCG 1706, Kisan, CO 1, Starr, TCG 1704 and TMV 9 were found as low resistant and DH 3-30, TCG 290, Ah 316/S and TCG 267 as susceptible cultivars against *H. armigera* population in the region of Andhra Pradesh.

According to Mahadevan *et al*. (1988), the genotype ICGS-50 of groundnut was resistant against *H. armigera* in Tamilnadu.

Yambhatnal (2010) conducted an experiment on screening of groundnut cultivars for susceptibility against major defoliators at UAS, Dharwad in and recorded maximum defoliation and number of larvae were observed in JL-24 followed by

GPBD-4. The genotypes *viz*., Mutant-III and ICGV- 86699 Tan recorded minimum damage and least number of larvae indicating their resistance.

Waykule *et al.* (2020) recorded population of *H. armigera* infesting groundnut at Latur (Maharashtra) and stated that the lowest *H. armigera* was recorded on germplasm ISK-I-2019-17 (0.2 larvae/5 plants) which is highly resistant germplasm. Highest number of pod borer were reported on G-2-52 (20 larvae/5 plants).

Anonymous (2025b) observed that among 46 screened groundnut genotypes only six genotypes/varieties *viz*., JVG-37, GJG-32, JSSP-85, Girnar-4, JSSP-82 and GG-HPS-2 showed least leaf damage by *S. litura*. But, in genotypes *viz.,* JL-24, JB-1598, TG-37A, JB-1664, JB-1643 and JSSP-83 recorded highest leaf damage by *S. litura* in groundnut crop.

Naghera *et al.* (2026) screened groundnut genotype against *H. armigera* infestation at JAU, Junagadh. The studies revealed that the genotype JVG-26 (0.53 larvae/plant) had minimum larval population and contradictorily, the highest infestation was observed in JVG-21 (1.56 larvae/plant). While, none of the genotypes were found highly resistant and highly susceptible against *H. armigera* and with that four genotypes were categorized as resistant, which includes JVG-26, JVG-19, JVB-LS-2591 and JB-1614.

12.3 Evaluation of different ready-mixed insecticides against *S. litura* and *H. armigera* infesting groundnut

S. litura

Solanki *et al.* (2022) tested the bio-efficacy of various insecticides against *S. litura* infesting soybean at JAU, Junagadh (Guj.) and resulted that chlorantraniliprole 10 + lambda cyhalothrin 5 ZC was most effective by lowest number of larvae (0.87/plant) and maximum yield (3002 kg/ha).

Dodiya *et al.* (2024) taken field trial on *S. litura* infesting groundnut crop at AAU, Anand (Guj.). Results revealed that, maximum reduction in larval population and damaged in plants were found in treatment emamectin benzoate 5 SG, followed by chlorantraniliprole 18.5 SC and chlorpyriphos 20 EC.

Makani *et al.* (2024) conducted experiment on soybean leaf eating caterpillar at JAU, Junagadh (Guj.). Of the tested insecticides, chlorantraniliprole 10 + lambda -cyhalothrin 5 ZC recorded the lowest (1.06 larvae/plant), which was statistically in line with novaluron 5.25 + emamectin benzoate 0.9 SC (1.25 larvae/plant) and novaluron 5.25 + indoxacarb 4.5 SC (1.38 larvae/plant) after 3 days of the first spray. A similar

trend was seen after 7 and 10 days of the first spray as well as 3, 7 and 10 days after the second spray.

Rathod *et al*. (2024) concluded that the highest mortality of *S. litura* in soybean was observed in chlorantraniliprole 10 + lambda-cyhalothrin 5 ZC (83.55%), followed by emamectin benzoate 5 + lufenuron 40 WG (80.03%) and novaluron 5.25 + emamectin benzoate 0.9 SC (77.66%).

Verma *et al.* (2024) stated that the overall mean larval population recorded after 1st and 2nd spray, treatment of chlorantraniliprole 10 + lambda-cyhalothrin 5 ZC was most effective (0.61 larvae/plant and 0.57 larvae/plant, respectively) followed by chlorantraniliprole 25g a.i./ha (0.78 larvae/plant and 0.66 larvae/plant, respectively) against *S. litura* infesting cabbage.

Dudhatra *et al.* (2024b) carried out a field experiment on *S. litura* infesting groundnut in *Kharif*, 2023 at JAU, Junagadh (Guj.) and stated that chlorantraniliprole 10 + lambda cyhalothrin 5 ZC 0.006% proved most effective after two sprays. It recorded the minimum leaf damage (4.62%) and highest pod & haulm yields (1584 and 3286 kg/ha, respectively).

H. armigera

Santharam *et al*. (2004) revealed that foliar spray of methoxyfenozide @ 200 g a.i./ha reduced the larval population of *H. armigera* significantly and resulted in increased pod yield in groundnut.

Swami and Kumar (2019) found that thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC at 175 ml/ha followed by thiamethoxam 12.6% + lambda cyhalothrin 9.5% ZC at 150 ml/ha was the most effective against black gram infesting pests *i.e*., *Maruca* spp., *H. armigera* and *S. litura*.

Harish *et al*. (2022) concluded that the *H. armigera* population on groundnut was found lowest in the treatment of chlorantraniliprole 18.5 SC @ 0.3 ml/L (2.3 larvae per meter row length) followed by quinalphos 25 EC @ 2 ml/L. The treatment of chlorantraniliprole 18.5 SC @ 0.3 ml/L recorded highest pod yield of 1556.8 kg/ha with an ICBR of 1:9.3.

Kumar and Kumar (2023) at Prayagraj (UP) recorded larval population of chickpea pod borer on 3rd, 7th and 14th days after spraying; which showed that treatment of chlorantraniliprole 18.5 SC (2.41 larvae/plant) was best followed by spinosad 45 SC (2.47 larvae per plant). Among the treatments evaluated, most effective and economical treatment was chlorantraniliprole (1:3.0).

Raghunatha *et al.* (2023) evaluated the bio-efficacy of novaluron 9.45 + lambda cyhalothrin 1.9 ZC against tomato fruit borer, *H. armigera* at Karnataka and found that novaluron 9.45 + lambda cyhalothrin 1.9 ZC @ 102 g. a.i./ha was most effective in reducing population of *H. armigera* with higher fruit yield and maximum C:B ratio. Least reduction in larval population was seen in novaluron 5.25 + indoxacarb 4.5 SC and in individual application of novaluron 10 EC.

Singh *et al*. (2023) conducted a study at Banda (UP) on chickpea and revealed that the indoxacarb 15.8 EC @ 50 g a.i./ha + chlorantraniliprole 18.5 SC @ 30 g a.i./ha was found most effective in reducing *H. armigera* population. Data stated that the crop treated with indoxacarb 15.8 EC @ 50 g a.i./ha + chlorantraniliprole 18.5 SC @ 30 g a.i./ha recorded highest yield and found to be the best treatments.

Jagmohan (2024) at Banda (UP) revealed that chlorantraniliprole 18.5 SC @ 30 g a.i./ha was confirmed as the most effective with least larval counts and efficacy against *S. litura* and *H. armigera*, respectively after two applications. This was followed by cyantraniliprole 10 OD @ 90 g a.i./ha and novaluron 5.25 + indoxacarb 4.5 SC @ 39.38 + 33.77 g a.i./ha giving maximum groundnut yield (22.37 q/ha) with 52% increase over untreated control.

Naghera *et al.* (2025) concluded that the chlorantraniliprole 9.30 + lambda-cyhalothrin 4.6 ZC, novaluron 5.25 + indoxacarb 4.5 SC and novaluron 5.25 + emamectin benzoate 0.9 SC were found most effective among all ready-mix insecticides evaluated against *H. armigera* infesting groundnut. Beta-cyfluthrin 8.49 + imidacloprid 19.81 OD 0.028% was found least effective against the *H. armigera*. The highest pod and haulm yield was recorded in treatment of chlorantraniliprole 9.30 + lambda-cyhalothrin 4.6 ZC.

12.4 Relative persistent toxicity of various insecticides against *S. litura* and *H. armigera* infesting groundnut

S. litura

Nukala and Acharya (2015) done investigation on comparative relative toxicity of some trending insecticides against *S. litura* at JAU, Junagadh (Guj.) confirmed that emamectin benzoate was the most toxic and effective insecticide as it's LC_{50} value was 0.000954. On the other hand, spinosad was found to be the least toxic with an LC_{50} value of 0.0158.

Karuppaiah *et al.* (2017) revealed that chlorantraniliprole 18.5% SC at dose (LC_{50}) ranging from 1-4 ppm and emamectin benzoate 5% SG at dose of 1-3 ppm were

most effective formulations for *S. litura*. While, conventional insecticides mixtures, chlorpyrifos 50% + cypermethrin 5% EC and profenofos 40%+ cypermethrin 4% EC were less effective for *S. litura* population.

Negi and Srivastava (2018) checked persistent toxicity of four insecticides on frenchbean and mulberry plants against 5 days old of *S. litura* and found that chlorantraniliprole + lambda-cyhalothrin 0.027% was most persistent (PT = 1841.60 and 2119.98) followed by cypermethrin + indoxacarb 0.02% (PT = 812.68 and 1764.26) on mulberry and frenchbean, respectively. While, emamectin benzoate 0.0019% (PT = 4.16) showed least persistence toxicity on mulberry.

Bhamare *et al.* (2020) investigated persistence and residual toxicity of different insecticides against *S. litura* in soybean at Latur (Maharashtra). The outcomes indicated that chlorantraniliprole 0.004% and emamectin benzoate 0.001% had highest persistent toxicity index (PT = 913.01 and 860.89, respectively) and LT_{50} values (7.59 and 6.69, respectively) against early instar larvae of *S. litura*.

Choudhary (2023) found that chlorantraniliprole 0.03% was most persistent insecticide with a PT value of 827.55 and the least persistent flubendiamide 0.02% (450.43) when the mortality was recorded at 24 hours after feeding (HAF) against *S. litura* infesting soybean.

Kandpal and Srivastava (2024) conducted experiment on persistent toxicity (PT) of 3 insecticides, 3 fungicides and their 9 combinations against 3 days old larvae of *S. litura* infesting soybean. The most persistent treatment was emamectin benzoate with a PT value 1050 followed by novaluron + indoxacarb (1016) at 72 hours after feeding.

Anonymous (2024b) confirmed that the treatment of chlorantraniliprole 10 + lambda-cyhalothrin 5 ZC was the most effective chemical against *S. litura* infesting castor followed by novaluron 5.25 + emamectin benzoate 0.9 SC and novaluron 5.25 + indoxacarb 4.5 SC. While, maximum larval population was recorded in the treatments of beta-cyfluthrin 8.49 + imidacloprid 19.81 OD and profenofos 40 + cypermethrin 4 EC.

H. armigera

Shinde *et al.* (2010) tested persistence and residual toxicity against 1st instar larvae of *H. armigera* on okra fruits and stated the order of residual efficacy of insecticides on fruits based on LT_{50} and PT values was: spinosad 0.005% (12.44 days and 1146.46) followed by indoxacarb 0.01% (12.22 days and 1138.2), profenofos

0.08% (11.42 days and 1082.2) and imidacloprid 0.004% (9.74 days and 1016.9). The spinosad was found to be most effective insecticide against *H. armigera*.

Sonune and Bhamare (2016) evaluated residual toxicity of insecticides against *H. armigera* infesting pigeon pea. Studies revealed that emamectin benzoate 0.0022% shows highest persistent toxicity (PT) value of (925.08, 920.52 and 898.60) and LT_{50} values 7.63, 7.52 and 7.27 days against 1st instar larvae of *H. armigera* after first, second and third spray, respectively.

Dake *et al.* (2017) stated that emamectin benzoate 0.002% gave the highest persistence toxicity index (PT = 944.55) and LT_{50} (18 days) against sunflower head borer *H. armigera* (Hubner) after application of insecticides as compared to the other insecticides.

Lande *et al.* (2018) tested different chemicals in laboratory against *H. armigera* and revealed that the flubendiamide 20 WDG proved most effective in recording highest PT value (914.20) followed by emamectin benzoate 5 SG, spinosad 45 SC and indoxacarb 15.8 EC recording 723.10, 695.90 and 636.50 PT values, respectively.

Bhamare *et al.* (2020) investigated persistence and residual toxicity of different insecticides against *H. armigera* infesting soybean at Latur (Maharashtra). The results indicated that chlorantraniliprole 0.004% and emamectin benzoate 0.001% had highest persistent toxicity index (PT = 953.68 and 913.48 & 885.64 and 875.80, respectively) and LT_{50} values (7.93 and 7.78 & 7.06 and 7.09 days, respectively) against 3rd instar larvae of *H. armigera* after first and second spray.

12.5 Evaluation of *Sl*NPV with plant oils for the management of *S. litura* infesting groundnut

Narasimhamurthy and Simon (2012) evaluated synergistic effect of *Sl*NPV with plant extracts to control tobacco caterpillar infesting cabbage and stated that the highest larval reduction (81.66%) was recorded in the *Sl*NPV + NSKE 5% followed by *Sl*NPV + neem oil 0.1% (73.33%). The other plant extracts like mustard oil 0.2%, chilli garlic extract 2.5%, calotropis leaf extract 2% and pongamia leaf extract 2% along with *Sl*NPV were recorded 62.78%, 60.26%, 55.38% and 53.75% larval reduction over control, respectively during first spray.

Binseena and Faizal (2024) shows that storable rehydratable bait formulations, wheat bran (65%) + wheat Flour (35%) + additives + *Sl*NPV (10^7) + pongum oil (3.0%) and wheat bran (65%) + wheat Flour (35%) + additives + *Sl*NPV (10^7) + neem oil (2.5%) recorded more larval death of 100% and 93.33%, respectively in laboratory

bioassays from 6 days after treatment. The highest mortality of *S. litura* larvae was recorded in the treatments with a combination of baits followed by *Sl*NPV spray compared to their single application. The prospective impact of storable baits infused with *Sl*NPV and botanical oils on larval mortality ranges from 96.67% for bait containing pongam oil to 90.00% for bait containing neem oil, subsequently succeeded by the application of NPV.

12.6 Evaluation of *Ha*NPV with plant oils for the management of *H. armigera* infesting groundnut

Rabindra *et al.* (1989) carried out field experiment in Karnataka to check the efficacy of various adjuvants with NPV to control *H. armigera* infesting chickpea. Addition of whole milk (20%), whole egg homogenate (10%), ranipal (0.5%), robinblue (0.5%) and cotton seed oil (5%) with a controlled droplet applicator effectively controlled the *H. armigera* by reduced pod damage and increased yields. Among them, addition of crude sugar to NPV gave the highest yield (796 kg/ha) with whole egg homogenate and cotton seed oil being equally effective (762.2 and 773.3 kg/ha, respectively).

Deotale *et al.* (2007) found that the highest reduction (83%) in larval population of *H. armigera* was recorded in the *Ha*NPV + folic acid 1.5% followed by *Ha*NPV + ranipal (76.86%) in chickpea crop. Other treatments *viz*., riboflavin 1.5%, pyridoxin 1.5%, mango and eucalyptus leaf extract 0.5% mixed with *Ha*NPV recorded 69.24, 68.33, 61.71 and 60.48 per cent larval reduction over control (*Ha*NPV alone), respectively.

Singh (2012) carried out an experiment to observe the field efficacy of *Ha*NPV with some adjuvants against *H. armigera* in Chickpea. Results showed that *Ha*NPV added with adjuvant increased the bio-efficacy than the alone but when NPV used in alternation with NSKE was significantly more effective.

Gayathridevi *et al.* (2014) observed that on the fourth day of treatment highest mean larval mortality of *H. armigera* (19.71%) was recorded in combination of soybean oil. While zero per cent mortality was observed in *Ha*NPV alone. On the sixth day, the highest larval mortality of *H. armigera* (82.65%) was recorded in soybean oil in all the concentrations followed by other oils; while 37% mortality was noticed in *Ha*NPV alone. On the tenth day, cent percent mortality was recorded in combination of *Ha*NPV with soybean oil and sunflower oil in all concentrations followed by other oils; while 75% mortality was found in *Ha*NPV alone.

Ibrahim *et al.* (2019) tested ten plant-derived extracts as UV protectant for the *Ha*NPV in laboratory. Among them black tea, green cabbage, dill and pepper provided excellent UV protection; these findings indicate that these plant extracts may be useful as UV protectants for the *Ha*NPV.

Manjula *et al.* (2025) showed that the combined treatment of *HaNPV* + Glycerol 0.1% + jaggery 1% + teepol 0.01% showed the highest larval reduction (1.43 and 1.17 larvae) of *H. armigera* and yield (12.95 and 13.25 q/ha) in field bean and pigeon pea crop, respectively. Thus, adjuvants played a vital role in retaining the persistence of *HaNPV* and enhanced yield of crops.

13. Materials and Methods

13.1 Succession of major insect pests infesting groundnut

13.1.1 Details of the field experiment

1.	**Objective of experiment**	:	To investigate the succession of major insect pests infesting groundnut
2.	**Location of experiment**	:	Main Oilseeds Research Station, JAU, Junagadh
3.	**Season and year**	:	*Kharif*, 2026 and 2027
4.	**Crop and variety**	:	Groundnut, GG-23
5.	**Plot size**	:	15.00 m × 7.20 m
6.	**Spacing**	:	45.00 cm × 10.00 cm
7.	**Seed rate**	:	100 kg/ha
8.	**Fertilizer**	:	12.5:25:50 N:P_2O_5:K_2O (kg/ha)

13.1.2 Methodology

In order to assess the succession of major insect pests in groundnut crop, the plot will be divided in to 40 equal quadrates of size 1.00 m × 1.00 m. All the other agronomical operations will be adopted as per the recommendations. The crop under the experiment will be kept free from insecticides throughout the season. Observations on major insect pests will be recorded twice a week on five randomly selected plants from each quadrat, from one week after germination until the harvest of crop. The mean population of major insect pests per plant will be worked out separately. The population of sucking insect pests will be recorded from three leaves (top, middle and bottom) per plant. While the larval population, number of egg masses (*S. litura*) and natural enemies will be recorded per plant.

In order to study the impact of different abiotic factors *viz*., temperature [maximum (Max T) and minimum (Min T)], relative humidity [morning (RH_1) and evening (RH_2)], bright sunshine (BSS), rainfall (RF), wind speed (WS) and vapour pressure [morning (VP_1) and evening (VP_2)] on insect pests population, a simple correlation and regression analysis between insect pest population and weather parameters will be worked out. The weekly meteorological data will be obtained from the meteorological observatory of Junagadh Agricultural University, Junagadh.

13.1.3 Observations to be recorded

1. No. of sucking insect pests from three leaves per plant
2. No. of larvae per plant
3. No. of egg masses per plant (*S. litura*)
4. Natural enemies (If any)

13.2 Screening of different varieties/genotypes against *S. litura* and *H. armigera* infesting groundnut

13.2.1 Details of the field experiment

1.	**Objective of experiment**	:	To screen different varieties/genotypes against *S. litura* and *H. armigera* infesting groundnut
2.	**Location of experiment**	:	Main Oilseeds Research Station, JAU, Junagadh
3.	**Season and year**	:	*Kharif*, 2026 and 2027
4.	**Crop**	:	Groundnut
5.	**Plot size**	:	4.00 m × 0.90 m (2 row)
6.	**Spacing**	:	45.00 cm × 10.00 cm
7.	**Treatment**	:	20 available varieties/genotypes provided by Main Oilseeds Research Station, JAU, Junagadh
8.	**Replication**	:	3
9.	**Design**	:	Randomized Block Design (RBD)
10.	**Seed rate**	:	100 kg/ha
11.	**Fertilizer**	:	12.5:25:50 N:P_2O_5:K_2O (kg/ha)

13.2.2 Methodology

To screen groundnut varieties/genotypes for resistance against *S. litura* and *H. armigera*, two lines of each varieties/genotype will be grown during *Kharif*, 2026 and 2027 at Main Oilseeds Research Station, JAU, Junagadh. The crop will be raised by adopting recommended agronomical practices. The experimental plot will be kept free from any insecticides for recording observations. After emergence of crop, five plants will be selected randomly to assess larval population during the vegetative, flowering and post-flowering stages. Yield will be recorded after harvesting and threshing of the crop.

13.2.2 Categorization of varieties/genotypes

The varieties/genotypes will be grouped into six categories of susceptibility *viz*., highly resistant, resistant, moderately resistant, moderately susceptible, susceptible and highly susceptible based on parameters *viz*., pest population. For the purpose, mean value of 20 individual varieties/genotypes ($\bar{X}i$) will be compared with mean value of all varieties/genotypes ($\bar{X}$) and standard deviation (Sd). The retransformed data will be used for the computation of $\bar{X}$, $\bar{X}i$ and SD in case of this parameter. The scale used for categorizing different varieties/genotypes will be under (Gami *et al.*, 2026).

Category of resistance	Scale for resistance
Highly resistant	$\bar{X}_i \leq (\bar{X} - 2SD)$
Resistant	$(\bar{X} - SD) \geq \bar{X}_i > (\bar{X} - 2SD)$
Moderately resistant	$\bar{X} \geq \bar{X}_i > (\bar{X} - SD)$
Moderately susceptible	$\bar{X} < \bar{X}_i \leq (\bar{X} + SD)$
Susceptible	$(\bar{X} + SD) < \bar{X}_i \leq (\bar{X} + 2SD)$
Highly susceptible	$\bar{X}_i > (\bar{X} + 2SD)$

13.2.3 Observations to be recorded

1. No. of larvae per plant
2. Pod and haulm yield (kg/ha)

13.3 Evaluation of different ready-mixed insecticides against *S. litura* and *H. armigera* infesting groundnut

13.3.1 Details of the field experiment

1.	**Objective of experiment**	:	To evaluate different ready-mixed insecticides against *S. litura* and *H. armigera* infesting groundnut
2.	**Location of experiment**	:	Main Oilseeds Research Station, JAU, Junagadh
3.	**Season and year**	:	*Kharif*, 2026 and 2027
4.	**Crop and variety**	:	Groundnut, GG-23
5.	**Gross plot size**	:	5.00 m × 2.70 m (6 row)
6.	**Net plot size**	:	4.00 m × 1.80 m (4 row)
7.	**Spacing**	:	45.0 cm × 10.0 cm
8.	**Seed rate**	:	100 kg/ha
9.	**Fertilizer**	:	12.5:25:50 N:P_2O_5:K_2O (kg/ha)
10.	**Design**	:	Randomized Block Design (RBD)
11.	**Treatments**	:	8
12.	**Replications**	:	3

Table 1. Details of insecticidal treatments

Tr. No.	Treatment detail	Conc. (%)	Dose (g or ml/10 l)	a. i. (g/ha)	Quantity of formulation (kg or l /ha)
T_1	Chlorantraniliprole 9.30 + Lambda-cyhalothrin 4.6 ZC	0.006	4 ml	18.60 + 9.20	0.20
T_2	Thiamethoxam 12.6 + Lambda-cyhalothrin 9.5 ZC	0.007	3 ml	18.90 + 14.25	0.15
T_3	Novaluron 5.25 + Emamectin benzoate 0.9 SC	0.009	15 ml	39.38 + 6.75	0.75
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC	0.015	15 ml	39.38 + 33.75	0.75
T_5	Profenophos 40 + Cypermethrin 4 EC	0.088	20 ml	400 + 40	1.00
T_6	Emamectin benzoate 5 + Lufenuron 40 WG	0.009	2 ml	3 + 24	0.10
T_7	Methoxyfenozide 20 + Chlorantraniliprole 5 SC	0.025	10 ml	100 + 25	0.50
T_8	Untreated Control	-	-	-	-

13.3.2 Application of treatments

All the insecticides will be applied in form of foliar spray with the help of knapsack sprayer. Spray fluid will be prepared by mixing measured quantities of water and insecticides. All necessary care will be taken to prevent the drift of insecticides to reach the adjacent plots. After initiation of the pest, first application of insecticides will be given. Need base subsequent applications will be given at fifteen days intervals.

13.3.3 Method of recording observations

For evaluating the field efficacy of the insecticides against *S. litura* and *H. armigera* on groundnut crop, five plants from each treatment (net plot) will be selected randomly. The number of larvae (both) will be recorded at 1 day before and 3, 7, 10 and 14 days after each spraying of the insecticides from five selected plant. The pod yield will be recorded after harvesting and threshing of the crop and converted to kilogram per hectare. Data obtained on larval populations will be converted into per cent reduction over control through following formula (Abbott, 1925).

$$\text{Per cent reduction over control} = \frac{C-T}{C} \times 100$$

Where,

T = Larval population (*S. litura* and *H. armigera*) from treated plot

C = Larval population (*S. litura* and *H. armigera*) from control plot

13.3.4 Yield and Economics

Groundnut will be harvested from each net plot and weighed separately. The harvested pod and haulm yield will be converted into kg/hectare. The percent increase yield over control will be also computed using the formula mentioned below given by Pradhan (1969).

$$\text{Yield increased (\%)} = \frac{T-C}{C} \times 100$$

Where,

T = Yield of respective treatment (kg/ha)

C = Yield from control (kg/ha)

The economics of all the treatments will be worked out by considering the price of groundnut pod and haulm yield, cost of insecticides used and labourer charges for spraying of insecticides. Incremental cost-benefit ratio (ICBR) will be also worked out to compare the economics of various treatments.

13.3.5 Observations to be recorded

1. No. of larvae per plant
2. No. of egg masses per plant (*S. litura*)
3. Pod and haulm yield (kg/ha)
4. No. of natural enemies per plant (If any)

13.4 Relative persistent toxicity of various insecticides against *S. litura* and *H. armigera* infesting groundnut

The lab experiment will be carried out in three repetitions by applying a completely randomised design (CRD) at the P.G. laboratory, Department of Entomology, College of Agriculture, JAU, Junagadh with aim to figure out the relative persistent toxicity of various insecticides. After 1, 5, 7, 10 and 14 days following each spraying, a leaf from the experiment 13.3 field will be collected and five *S. litura* and *H. armigera* (keep individually) larvae each will be artificially released on it. For maintaining turgidity of leaves, the entire treatment will be conducted in a Petri plate with blotting paper lining at the bottom. The modified formula gave by Henderson and Tilton (1955) will be used to calculate the percent mortality.

$$\text{Per cent mortality} = 100 \times \left[1 - \frac{T_a \times C_b}{T_b \times C_a}\right]$$

Where,

T_b = Number of insects observed before treatment in treated plot

T_a = Number of insects observed after treatment in treated plot

C_b = Number of insects observed before treatment in control plot

C_a = Number of insects observed after treatment in control plot

Per cent mortality will be corrected using Abbott's formula (Abbott, 1925) as given below:

$$P = \left(\frac{P' - C}{100 - C}\right) \times 100$$

Where,

P = Corrected mortality percentage in the test insect

P' = Observed mortality percentage in the test insects

C = Per cent mortality in control

The zero and cent per cent mortality will be removed by using the formula: (1/4n) × 100 and (1-1/4n) × 100 given by Bartlet (1947); where n = number of larvae per treatment.

The data thus obtained will be angularly transformed and subjected to statistical analysis. The persistent toxicity (PT) and relative persistent toxicity (RPT) for each of the insecticide against *S. litura* and *H. armigera* will be worked out as per the following formula suggested by Sarup *et al*. (1970).

Persistent toxicity (PT) = Period of time (P) × Average toxicity of insecticides

$$\text{Relative Persistent Toxicity} = \frac{\text{Persistent toxicity of test insecticides}}{\text{Persistent toxicity of standard insecticides}}$$

13.5 Evaluation of *Sl*NPV with plant oils for the management of *S. litura* infesting groundnut

13.5.1 Details of the field experiment

1.	**Objective of experiment**	:	To evaluate *Sl*NPV with plant oils for the management of *S. litura* infesting groundnut
2.	**Location of experiment**	:	Main Oilseeds Research Station, JAU, Junagadh
3.	**Season and year**	:	*Kharif*, 2026 and 2027
4.	**Crop and variety**	:	Groundnut, GG-23
5.	**Gross plot size**	:	5.00 m × 2.25 m (5 row)
6.	**Net plot size**	:	4.00 m × 1.35 m (3 row)
7.	**Spacing**	:	45.0 cm × 10.0 cm
8.	**Seed rate**	:	100 kg/ha
9.	**Fertilizer**	:	12.5:25:50 N:P_2O_5:K_2O (kg/ha)
10.	**Design**	:	Randomized Block Design (RBD)
11.	**Treatments**	:	7
12.	**Replications**	:	3

Table 2. Details of *Sl*NPV treatments

Tr. No.	Treatment detail	Concentration (%)
T_1	*Sl*NPV alone	450 LE
T_2	*Sl*NPV + Neem oil	450 LE + 0.5%
T_3	*Sl*NPV + Cotton oil	450 LE + 0.5%
T_4	*Sl*NPV + Soybean oil	450 LE + 0.5%
T_5	*Sl*NPV + Sunflower oil	450 LE + 0.5%
T_6	SlNPV + Sesame oil	450 LE + 0.5%
T_7	Control	-

13.5.2 Application of treatments

All the treatments will be applied in the form of foliar spray with the help of knapsack sprayer. All the plant oils will be taken from local market and NPV (Sawaj-NPV) from Biocontrol Laboratory, JAU, Junagadh. Different adjuvants prepared in the laboratory at desired concentration will be added to *Sl*NPV spray suspension. Spray fluid will be prepared by mixing measured quantities of water and *Sl*NPV. All necessary care will be taken to prevent the drift of insecticides to reach the adjacent plots. After initiation of the pest first application of insecticides will be given. Need base subsequent applications will be given at fifteen days intervals.

13.5.3 Method of recording observations

For evaluating the field efficacy of the NPV against *S. litura* on groundnut crop, five plants will be randomly selected from each plot to record the observation on larval population. The number of larvae (*S. litura*) will be recorded at 1 day before and 3, 7, 10 days after each spraying from each selected plot.

Data obtained on larval populations will be converted into per cent reduction over control through following formula (Abbott, 1925).

$$\text{Per cent reduction over control} = \frac{C-T}{C} \times 100$$

Where,

T = Larval population (*S. litura*) from treated plot

C = Larval population (*S. litura*) from control plot

13.5.4 Yield and Economics

The crop will be harvested from each net plot and weighed separately. The harvested pod and haulm yield will be converted into kg/hectare. The percent increase yield over control will be also calculated by using the formula mentioned below given by Pradhan (1969).

$$\text{Yield increased (\%)} = \frac{T-C}{C} \times 100$$

Where,

T = Yield of respective treatment (kg/ha)

C = Yield from control (kg/ha)

The economics of all the treatments will be worked out by considering the price of groundnut pod and haulm yield, cost of insecticides used and labourer charges for

spraying of insecticides. Incremental cost-benefit ratio (ICBR) will be also worked out to compare the economics of various treatments.

13.5.5 Observations to be recorded

1. No. of *S. litura* larvae per plant
2. Pod and haulm yield (kg/ha)

13.6 Evaluation of *Ha*NPV with plant oils for the management of *H. armigera* infesting groundnut

13.6.1 Details of the field experiment

1.	**Objective of experiment**	:	To evaluate *Ha*NPV with plant oils for the management of *H. armigera* infesting groundnut
2.	**Location of experiment**	:	Main Oilseeds Research Station, JAU, Junagadh
3.	**Season and year**	:	*Kharif*, 2026 and 2027
4.	**Crop and variety**	:	Groundnut, GG-23
5.	**Gross plot size**	:	5.00 m × 2.25 m (5 row)
6.	**Net plot size**	:	4.00 m × 1.35 m (3 row)
7.	**Spacing**	:	45.0 cm × 10.0 cm
8.	**Seed rate**	:	100 kg/ha
9.	**Fertilizer**	:	12.5:25:50 N:P_2O_5:K_2O (kg/ha)
10.	**Design**	:	Randomized Block Design (RBD)
11.	**Treatments**	:	7
12.	**Replications**	:	3

Table 3. Details of *Ha*NPV treatments

Tr. No.	Treatment detail	Concentration (%)
T_1	*Ha*NPV alone	250 LE
T_2	*Ha*NPV + Neem oil	250 LE + 0.5%
T_3	*Ha*NPV + Cotton oil	250 LE + 0.5%
T_4	*Ha*NPV + Soybean oil	250 LE + 0.5%
T_5	*Ha*NPV + Sunflower oil	250 LE + 0.5%
T_6	*Ha*NPV + Sesame oil	250 LE + 0.5%
T_7	Control	-

13.6.2 Application of treatments

The method of Application of treatments will be as per 13.5.2.

13.6.3 Method of recording observations

The method of recording observations will be as per 13.5.3.

13.6.4 Yield and Economics

The yield and economics will be worked as per 13.5.4.

13.6.5 Observations to be recorded

1. No. of *H. armigera* larvae per plant
2. Pod and haulm yield (kg/ha)

14. Statistical Analysis

Statistical analysis of data will be carried out by following the standard procedures given by Panse and Sukhatme (1985).

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Signature of Student **Signature of Major Guide**

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CERTIFICATE

This is to certify that **GAMI KUSHAL NITESHKUMAR (Registration No.: 1010125004)** has made an oral presentation of the synopsis of research project entitled **"Studies on pest succession and management of *Spodoptera litura* (Fab.) and *Helicoverpa armigera* (Hub.) infesting groundnut"** in **Department of Entomology, College of Agriculture, JAU, Junagadh** dated **27/03/2026** in the presence of advisory committee members, other faculty members and post graduate students. The student has incorporated all the suggestions.

Signature of major guide and the members of the advisory committee

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